

PATENT ABSTRACTS OF JAPAN

(11) Publication number :

2002-300004

(43) Date of publication of application : 11.10.2002

(51)Int.Cl.

H03H 9/64

H03H 9/145

H03H 9/25

(21)Application number : 2001-096114

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(22) Date of filing : 29.03.2001

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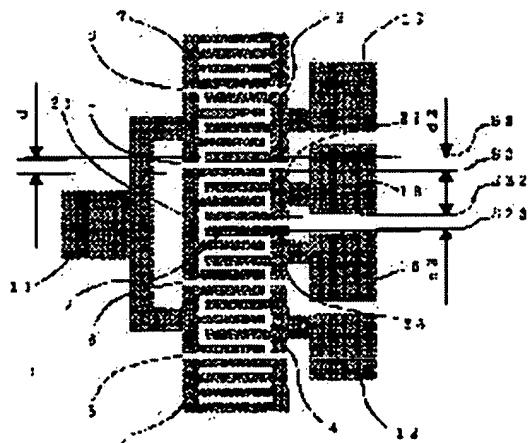
OTSUKA KAZUHIRO

(54) SURFACE ACOUSTIC WAVE FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a surface acoustic wave filter that has an excellent insertion loss and has an excellent amplitude and phase balance characteristics.

SOLUTION: This invention provides the surface acoustic wave filter in which a balance signal electrode for balance input/output and an unbalance signal electrode for unbalance input/output is placed on a piezoelectric substrate 1, the balance signal electrode is formed by interdigitally opposing a plurality of interdigital signal electrodes among electrode fingers placed at both ends of one interdigital floating electrode or interdigital ground electrode and the interdigital signal electrodes adjacent to each other are opposed to each other in phase.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

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[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's
decision of rejection]

[Date of requesting appeal against examiner's
decision of rejection]

[Date of extinction of right]

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(19) 日本国特許庁 (JP)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開2002-300004

(P2002-300004A)

(43) 公開日 平成14年10月11日 (2002. 10. 11)

(51) Int. C1. 7

H 03 H 9/64
9/145
9/25

識別記号

F I

H 03 H 9/64
9/145
9/25

テマコード (参考)

Z 5J097
Z
Z

審査請求 未請求 請求項の数 3 O L

(全 8 頁)

(21) 出願番号 特願2001-96114 (P2001-96114)

(22) 出願日 平成13年3月29日 (2001. 3. 29)

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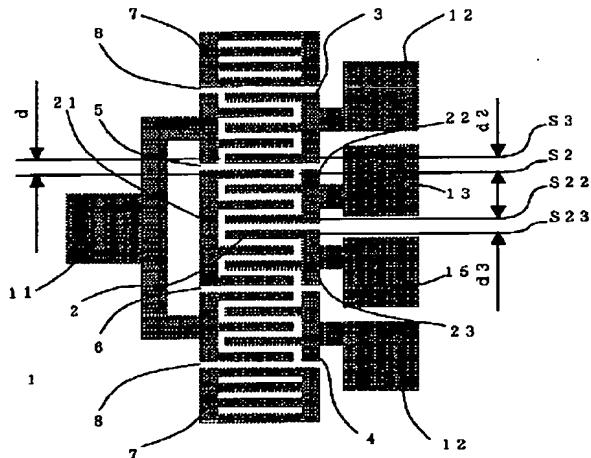
F ターム (参考) 5J097 AA01 AA12 AA16 AA19 BB03
CC02 CC08 DD04 DD07 DD13
DD25 EE09 GG03 GG04 GG05
HA02 HA04 KK04

(54) 【発明の名称】弾性表面波フィルタ

(57) 【要約】

【課題】挿入損失が良好であり、振幅および位相の平衡度の良好な弾性表面波フィルタを提供すること。

【解決手段】圧電基板1上に、平衡入力または平衡出力を行う平衡信号電極と、不平衡出力または不平衡入力をを行う不平衡信号電極とを配設し、平衡信号電極は、1つの歯状浮き電極または歯状接地電極に対し、該電極の両端に位置する電極指の間に、隣接させた複数の歯状信号電極を噛み合わせるように対向させて成るとともに、隣合う歯状信号電極が互いに逆位相である弾性表面波フィルタとする。



【特許請求の範囲】

【請求項1】 圧電基板上に、平衡入力または平衡出力をを行う平衡信号電極と、不平衡出力または不平衡入力をを行う不平衡信号電極とを配設して成る共振器型の弾性表面波フィルタであって、前記平衡信号電極は、1つの櫛歯状浮き電極または櫛歯状接地電極に対し、該電極の両端に位置する電極指の間に、隣接させた複数の櫛歯状信号電極を噛み合わせるように対向させて成るとともに、隣合う櫛歯状信号電極が互いに逆位相であることを特徴とする弾性表面波フィルタ。

【請求項2】 前記隣合う櫛歯状信号電極の端部に位置する電極指どうしが隣接していることを特徴とする請求項1に記載の弾性表面波フィルタ。

【請求項3】 前記平衡信号電極の中央から隣合う不平衡信号電極の中央までの平均電極指幅を、共振器全体の平均電極指幅よりも小さくしたことを特徴とする請求項1に記載の弾性表面波フィルタ。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、圧電基板上に平衡入力または平衡出力をを行う平衡信号電極と、不平衡出力または不平衡入力をを行う不平衡信号電極とを備えて成る共振器型の弾性表面波フィルタに関するものである。

【0002】

【従来技術とその課題】 近年、移動体通信機器等の小型・軽量化および低コスト化のため、使用部品の削減が進められ、弾性表面波フィルタに新たな機能の付加が要求されてきている。その1つに不平衡入力-平衡出力型または平衡入力-不平衡出力型に構成できるようになるとといった要求がある。ここで平衡入力または平衡出力とは、信号が2つの信号線路間の電位差として入力または出力するものをいい、各信号線路の信号は振幅が等しく、位相が逆相になっている。これに対して、不平衡入力または不平衡出力とは、信号がグランド電位に対する1本の線路の電位として入力または出力するものをいう。

【0003】 従来の弾性表面波フィルタは、一般的に不平衡入力-不平衡出力型弾性表面波フィルタ（以下、不平衡型弾性表面波フィルタという）であるため、弾性表面波フィルタの後段に接続される回路や電子部品が平衡入力型となっている場合は、弾性表面波フィルタと後段との間に、不平衡-平衡変換器（以下、バランともいう）を挿入した回路構成を探っていた。同様に弾性表面波フィルタ前段の回路や電子部品が平衡出力型となっている場合は、前段と弾性表面波フィルタとの間にバランを挿入した回路構成となっていた。

【0004】 現在、バランを削除するために、弾性表面波フィルタに不平衡-平衡変換機能または平衡-不平衡変換機能を持たせた、不平衡入力-平衡出力型弾性表面波フィルタまたは平衡入力-不平衡出力型弾性表面波フ

ィルタ（以下、平衡型弾性表面波フィルタという）の実用化が進められている。

【0005】 例えば、複数個並設したIDT（Inte r Digital Transducer）電極の弾性表面波伝搬路の両端に、弾性表面波を効率よく共振させるための反射器電極が設けられた共振器型電極パターンにおいて、通過帯域内の振幅と位相の平衡度の向上が求められている。ここで、振幅と位相の平衡度とは、信号が2つの信号線路間の電位差として入力または出力するもので、各信号線路の信号の振幅の大きさが等しいほど振幅の平衡度が優れており、また、各信号の位相の差が180°に等しいほど位相の平衡度が優れているといえる。

【0006】 図3、4に従来までの平衡入出力に対応した共振器型弾性表面波フィルタを示す。圧電基板101上に配置させたIDT電極102は、一对の互いに対向させた櫛歯状電極に電界を加え、弾性表面波を励振させるものである。その原理により、IDT電極102に入力信号を加えることで、励振された弾性表面波がIDT電極102の両側に位置する、出力信号用のIDT電極103、104に伝搬される。IDT電極103、104の一方の櫛状電極から出力信号端子113、他方から出力信号端子115へ信号が伝わり平衡出力される。また、図4は2段接続することによりフィルタ特性の帯域外減衰量の向上ができる構成となっている。

【0007】 上記のような共振器型弾性表面波フィルタでは、IDT電極103、104の対向する櫛状電極の電極本数、配置された位置、または、寄生容量を発生させる要因となる周辺の電極パターンなど構造が異なるために、出力信号端子113、115に伝わる信号が互いに振幅が異なり、また位相が逆相からずれてしまい、その結果、平衡度の劣化した共振器型弾性表面波フィルタしか得られなかった。

【0008】 近年、弾性表面波フィルタは各種通信機器の小形化、無調整化に一役を担っている。そして、通信機器の高周波数化、高機能化の進展にともない、弾性表面波フィルタの広帯域化の要求が益々増大してきている。例えば、900MHz帯携帯電話用のフィルタとしては、実効通過帯域幅3.5MHz以上（比帯域幅約3.7%以上）の高性能な広帯域フィルタが要求されている。なお、比帯域幅BRは、 $BR = BW/f_c$ （BWは帯域内挿入損失が3dBにおける通過帯域幅、f_cは帯域内挿入損失が3dBにおける通過帯域の中心周波数）であらわすことができる。

【0009】 このような広帯域化を実現するために、従来、様々な方法が提案されている。例えば、3個のIDT（Inte r Digital Transducer）電極（1対の櫛歯状電極を互いに対向させた電極）を設け、縦1次モードと縦3次モードを利用した、いわゆる2重モード弾性表面波共振子フィルタが知られてい

る。

【0010】図3に示すように、両端に位置する反射器電極107により弾性表面波が反射され、反射器電極107、107間で定在波となる。この定在波のモードには、3つのIDT電極により1次モードとその高次(3次)モードが含まれる。これらのモードで発生する共振周波数で通過特性が得られるため、共振周波数の間隔を制御することにより、通過帯域を広くさせることができる。なお、図中、105、106はIDT電極間部位、108はIDT電極と反射器電極間部位、111は入力信号端子、112は接地端子、113、115は出力信号端子である。

【0011】従来、このモード間の周波数制御に、全てのIDT電極を同じピッチLにし、かつ、中央およびその両側に位置するIDT電極の端部(IDT電極間部位)105、106における電極指中心間の間隔dの制御により、前記のモード間の周波数を制御する方法がとられていた。また、出力信号用のIDT電極に容量を付加して周波数を制御していた。

【0012】このため、従来の2重モード弾性表面波共振器フィルタでは、例えば圧電基板としてLiTaO₃単結晶の基板を用いた場合、比帯域幅(中心周波数に対する通過帯域幅の値)は約0.40%程度(特開平1-231417号公報を参照)、または高々2%程度しか得られていなかった(特開平4-40705号公報を参照)。また、最大の帯域幅で3.7%が実現されているが(特開平7-58581号公報を参照)、前記したように、システムの占有帯域幅の比率が3.7%であるため、フィルタとしては温度変動と作製時のばらつき変動の周波数分が必要であることから、広い通過帯域幅が要求されている携帯電話等の通信機器への適用には問題があった。

【0013】そこで本発明は、平衡型として動作可能で振幅と位相の平衡度が良好で高品質な弾性表面波フィルタ、さらには挿入損失が良好であり、通過帯域幅の広い弾性表面波フィルタとして機能できる、優れた弾性表面波フィルタを提供することを目的とする。

【0014】

【課題を解決するための手段】前記目的を達成するため、本発明の共振器型の弾性表面波フィルタは、圧電基板上に、平衡入力または平衡出力を行う平衡信号電極と、不平衡出力または不平衡入力を行う不平衡信号電極とを配設して成り、前記平衡信号電極は、1つの櫛歯状浮き電極または櫛歯状接地電極に対し、該電極の両端に位置する電極指の間に、隣接させた複数の櫛歯状信号電極を噛み合わせるように対向させて成るとともに、隣合う櫛歯状信号電極が互いに逆位相であることを特徴とする。また、隣合う櫛歯状信号電極の端部に位置する電極指どうしが隣接していることを特徴とする。また、平衡信号電極の中央から隣合う不平衡信号電極の中央までの

平均電極指幅を共振器全体の平均電極指幅よりも小さくしたことを特徴とする。

【0015】

【発明の実施の形態】以下、本発明の実施形態を模式的に図示した図面に基づいて詳細に説明する。

【0016】図1に本発明に係る弾性表面波フィルタの平面図を示す。不平衡信号電極であるIDT電極3、4および平衡信号電極であるIDT電極2を複数配置させ、その両端に反射器電極7を載置させることは、従来構造と同様であるが、本発明の構造では、IDT電極2が、1つの櫛歯状浮き電極または櫛歯状接地電極21に対し、その電極の両端に位置する電極指の間に、隣接させた複数の櫛歯状信号電極22、23を噛み合わせるように対向させて成るとともに、隣合う櫛歯状信号電極22、23が互いに逆位相に成るように構成され、それぞれの電極部が平衡信号電極として形成されている。上記構造により振幅および位相バランスを制御していることを特徴としている。なお、IDT電極2、3、4および反射器電極7の電極指の本数は数本～数100本にもおよぶため、その形状を簡略化して図示している。以下、弾性表面波フィルタを示す図面においては、全て同様に簡略化して図示するものとする。

【0017】ここで、3個のIDT電極2～4のうち、中央に配置されたIDT電極2は不平衡入力用または不平衡出力用のIDT電極であり、その両端に配置されたIDT電極3、4はそれぞれ平衡入力用または平衡出力用のIDT電極である。出力用のIDT電極を形成している1対の電極のうち、一方を出力1とすると、他方が出力1に対して振幅が同じ大きさで位相が逆相になっている出力2となり、平衡型の動作を行う。

【0018】不平衡入出力部の信号線S3と平衡出入力部の信号線S2の間隔d2とフィルタ特性の相関を調査したところ、d2が大きくなるほど互いの電磁界の干渉が小さくなり、その結果平衡出入力部の振幅と位相の平衡度が改善され、逆にd2が小さくなるほど弾性表面波の伝搬損失が小さくなり、その結果フィルタ特性の挿入損失が小さくなり、最適な構造はd2が弾性表面波の波長をλとするλ+dに等しくなるところでもっとも挿入損失が小さく、振幅と位相の平衡度もよくなることが判明した。

【0019】また2つの平衡出入力部の信号線S22、S23の間隔d3についても調査したところ、隣合う櫛歯状信号電極の端部に位置する電極指どうしが隣接し、d3がλ/2に近づくほどフィルタ特性の挿入損失が小さくなることが判明した。すなわち、本発明の構造にすることにより、フィルタ特性の挿入損失、振幅と位相の平衡度ともに優れた弾性表面波フィルタを提供することができる事が判明した。

【0020】次に、本発明の電極構成の変形例を図2、9、10、11に示す。

【0021】図2は共振器型フィルタを2段接続した弾性表面波フィルタである。不平衡信号電極であるIDT電極91へ不平衡信号が入力され、IDT電極92から不平衡信号が出力される。そして、IDT電極92と隣の共振器型フィルタの不平衡信号電極3、4が接続される。上記構造によりフィルタ特性の帯域外減衰量を大きく向上させることができる。

【0022】図9は、平衡信号電極2の中央から隣合う不平衡信号電極3、4の中央までのIDT電極間部位5、6の平均電極指幅を共振器全体の平均電極指幅よりも小さくしたことを特徴とする。上記構造によりフィルタ特性の通過帯域幅を制御することができる。

【0023】図10は共振器型フィルタを2段接続し、平衡信号電極であるIDT電極2の中央から隣合う不平衡信号電極であるIDT電極3、4の中央までのIDT電極間部位5、6の平均電極指幅を共振器全体の平均電極指幅よりも小さくしたことを特徴とする。上記構造によりフィルタ特性の帯域外減衰量を大きく向上させることができ、さらに、フィルタ特性の通過帯域幅を制御することができる。

【0024】かくして、前記のような条件を満足するIDT電極構造の弾性表面波フィルタによれば、IDT電極対数が最適化された組み合わせとなり、その結果、比帯域幅、振幅および位相の平衡度の特性が良好な品質的に優れたフィルタを作製することができる。

【0025】図11は平衡信号電極の櫛歯状電極を4つ噛み合わせたことを特徴とする。これにより、電極を4つ使用することにより設計パラメータを増やすことができ、より要求仕様に適した設計を行えることができる。

【0026】なお、図1においては弾性表面波フィルタを1セクションの共振器で構成したが、これに限定されるものではなく、共振器を2個以上継続接続した弾性表面波フィルタやIDT電極を5個以上並べた弾性表面波フィルタにおいても本発明を適用することができる。

【0027】また、図2、9、10、11の弾性表面波フィルタの電極構造においてもこれに限定されるものではなく、2つの反射器電極の間に少なくとも3つのIDT電極を配するとともに、これら3つのIDT電極のうち中央に位置するIDT電極を不平衡入力部または不平衡出力部とし、かつ両端に位置するIDT電極を平衡出力部または平衡入力部としたものであれば、多数段に構成したりすることもできる。

【0028】また、弾性表面波フィルタ用の圧電基板1として、36°±3°YカットX伝搬タンタル酸リチウム単結晶、42°±3°YカットX伝搬タンタル酸リチウム単結晶、64°±3°YカットX伝搬ニオブ酸リチウム単結晶、41°±3°YカットX伝搬リチウム単結晶、45°±3°XカットZ伝搬四ホウ酸リチウム単結晶は電気機械結合係数が大きく、かつ、周波数温度係数が小さいため圧電基板として好ましい。圧電基板の厚み

は0.1mm～0.5mm程度がよく、0.1mm未満では圧電基板がもろくなり、0.5mm超では材料コストと部品寸法が大きくなり、使用できない。

【0029】また、IDT電極2、3、4は、AlもしくはAl合金(Al-Cu系、Al-Ti系)からなり、蒸着法、スパッタ法、またはCVD法などの薄膜形成法により形成する。電極厚みは0.1μm～0.5μm程度とすることが弾性表面波フィルタとしての特性を得るうえで好適である。

10 【0030】さらに、本発明に係る弾性表面波フィルタの電極および圧電基板上の弾性表面波伝搬部にSi、SiO₂、SiNx、Al₂O₃を保護膜として形成して、導電性異物による通電防止や耐電力向上を行ってもかまわない。

【0031】

【実施例】本発明に係る弾性表面波フィルタを具体的に試作した実施例について説明する。

【0032】38.7°YカットのLiTaO₃単結晶の圧電基板上に、図1に示すようなAl(99wt%)～Cu(1wt%)による微細電極パターンを形成した。IDT電極2の対数は16対、IDT電極3、4の対数は11対、電極の周期はIDT電極2、3、4ともに2.1μm、IDT電極2～3間または2～4間のIDT電極の端部における電極指中心間の間隔dは3.3μmとした。パターン作製には、スパッタリング装置、縮小投影露光機(ステッパー)、およびRIE(Reactive Ion Etching)装置によりフォトリソグラフィを行った。

【0033】まず、基板材料をアセトン・IPA等によって超音波洗浄し、有機成分を落とした。次に、クリーンオーブンによって充分に基板乾燥を行った後、電極の成膜を行った。電極の成膜にはスパッタリング装置を使用し、Al-Cu 1wt%合金から成る材料を用いた。このときの電極膜厚は約0.2μmとした。

【0034】次に、フォトレジストを約0.5μmの厚みにスピンコートし、縮小投影露光装置(ステッパー)により、所望形状にパターニングを行ない、現像装置にて不要部分のフォトレジストをアルカリ現像液で溶解させ、所望パターンを表出した後、RIE(Reactive Ion Etching)装置により電極膜のエッチングを行ないパターニングを終了し、梯子型弾性表面波フィルタを構成する弾性表面波共振器の電極パターンを得た。

【0035】この後、前記電極の所定領域上に保護膜を作製した。すなわち、CVD(Chemical Vapour Deposition)装置により、電極パターンおよび圧電基板上にSiO₂を約0.02μmの厚みに形成した。その後、フォトリソグラフィによってフォトレジストのパターニングを行ない、RIE装置等でワイヤボンディング用窓開け部のエッチングを行ない、

保護膜パターンを完成した。

【0036】次に、基板をダイシング線に沿ってダイシング加工を施し、チップごとに分割した。そして、各チップをダイボンド装置にてピックアップし、シリコーンを主成分とする樹脂を用いパッケージ内に接着した。この後、約160℃の温度において乾燥・硬化させた。パッケージは3mm角の積層構造のものを用いた。

【0037】次に、30μmΦAuワイヤをパッケージの電極部とチップ上のA1電極パッド上にボールボンディングした後、リッドをパッケージに被せ、封止機にて溶接封止して弾性表面波フィルタを完成した。なお、チップ上のグランド電極は各々分離して配線し、Auボールボンディングにてパッケージ上のグランド電極にボンディングを行った。

【0038】比較用サンプルとして図3に示すような微細電極パターンも上記と同様な工程で作製を行った。IDT電極102の対数は16対、IDT電極103、104の対数は11対、電極の周期はIDT電極102、103、104ともに2.1μm、IDT電極102-103間または102-104間のIDT電極の端部における電極指中心間の間隔dは3.3μmとした。

【0039】次に、本実施例における弾性表面波フィルタの特性測定を行った。0dBmの信号を入力し、周波数842.5MHz～1042.5MHz、測定ポイント数801ポイントの条件および周波数10MHz～6GHz、測定ポイント401ポイントの条件にて測定した。サンプル数は30個、測定機器はアジレント・テクノロジー社製ネットワークアナライザ8753Dである。

【0040】通過帯域近傍の周波数特性グラフを図5、6に示す。ここで、図5はフィルタの伝送特性を表す挿入損失の周波数依存性（図中51）および反射信号の大きさを評価する比率VSWR（Voltage Standing Wave Ratio）の周波数依存性（図中52）を示すグラフである。また、図6はフィルタ特性の平衡度を示すグラフであり、出力信号端子13から出力された挿入損失の周波数特性と出力信号端子15から出力された挿入損失の周波数特性の差を振幅の平衡度とする。また、出力信号端子13から出力された位相の周波数特性と出力信号端子15から出力された位相の周波数特性の差から180°を差し引いた値を位相の平衡度とする。振幅の平衡度が0dBであり位相の平衡度が0°であるほど弾性表面波フィルタの平衡度が優れていると評価できる。

【0041】本発明品のフィルタ特性は非常に良好であった。図6に示すように、通過帯域内925MHz～960MHzの振幅の平衡度61は約±0.7dB以下であり、および位相の平衡度62は約±7°以下であった。これに対して、比較サンプルとして作製した従来構造の弾性表面波フィルタは、図7、8に示すとおり、通

過帯域内925MHz～960MHzの振幅の平衡度81は約±1.4dB以下であり、位相の平衡度82は約±15°以下であった。それぞれ約0.7dB、約8°の改善が見られた。また、本発明品の通過帯域の挿入損失51は約2.4dB以下、VSWR52は2.7以下であるのに対し、従来品は挿入損失71が約3.1dB以下、VSWR72は3.6以下であり、それぞれ約0.7dB、0.9の改善が見られた。

【0042】また、弾性表面波フィルタの小型化が要求されているため上記実施例の弾性表面波フィルタをフリップチップ実装により作製し、評価を行った。すなわち、保護膜パターンを形成した後、パンプ形成装置によりパンプ形成用電極パターンにAuのパンプを形成した。次に、ダイシングにより、弾性表面波素子を個々に切り出した。次に、2.5×2.0mm角のセラミックパッケージにフリップチップボンディング装置により、個々に切り出した弾性表面波素子を1つ、セラミックパッケージ内に接着し、N2雰囲気中でペークを行った。次に、封止装置によりパッケージに金属製のキャップを被せてパッケージ内を密封し、弾性表面波フィルタを作製した。上記構造のフィルタの特性を測定した結果、上記と同様な結果が得られることを確認できた。

【0043】【発明の効果】以上説明したように、本発明の弾性表面波フィルタは、共振器型の弾性表面波フィルタであって、平衡信号電極は、1つの歯状浮き電極または歯状接地電極に対し、該電極の両端に位置する電極指の間に、隣接させた複数の歯状信号電極を噛み合わせるように対向させて成るとともに、隣合う歯状信号電極が互いに逆位相であることを特徴とする。上記構造の特に歯状浮き電極または歯状接地電極が平衡信号電極の両端に位置するような構成により、不平衡電極と平衡電極の電磁界の干渉を小さくすることができ、その結果、平衡信号を制御することができ、振幅および位相の平衡度が良好な品質的に優れた弾性表面波フィルタを実現することができる。

【0044】また、本発明の弾性表面波フィルタは、隣合う歯状信号電極の端部に位置する電極指どうしが隣接していることを特徴とする。上記構造の電極指の間隔を制御することにより平衡信号電極22、23の位相の差を180°に近づけることができ、その結果、位相の平衡度が良好な品質的に優れた弾性表面波フィルタを実現することができるまた、本発明の弾性表面波フィルタは、平衡信号電極の中央から隣合う不平衡信号電極の中央までの平均電極指幅を共振器全体の平均電極指幅よりも小さくしたことを特徴とする。上記構造の平均電極指幅をそれぞれ変化させることにより弾性表面波の縦1次モードと縦3次モードを制御することができる。

【0045】以上により、フィルタ特性の通過帯域幅を広帯域化した品質的に優れた弾性表面波フィルタを実現

することができる。

【図面の簡単な説明】

【図1】本発明の弾性表面波フィルタの構成例を模式的に示す平面図である。

【図2】本発明の弾性表面波フィルタの2段接続の構成例を模式的に示す平面図である。

【図3】従来の弾性表面波フィルタの構成例を示す平面図である。

【図4】従来の弾性表面波フィルタの2段接続の構成例を示す平面図である。

【図5】本発明の弾性表面波フィルタにおける通過帯域近傍の周波数特性を示すグラフである。

【図6】本発明の弾性表面波フィルタにおける通過帯域近傍の振幅および位相の平衡度を示すグラフである。

【図7】従来の弾性表面波フィルタにおける通過帯域近傍の周波数特性を示すグラフである。

【図8】従来の弾性表面波フィルタにおける通過帯域近傍の振幅および位相の平衡度を示すグラフである。

【図9】本発明に係る1段構成の弾性表面波フィルタを模式的に示す電極構成図である。

【図10】本発明に係る2段接続の弾性表面波フィルタを模式的に示す電極構成図である。

【図11】本発明に係る弾性表面波フィルタの変形例を

模式的に示す電極構成図である。

【符号の説明】

1, 101 : 圧電基板
2, 3, 4, 91, 92, 102, 103, 104 : I D T電極

5, 6, 105, 106 : I D T電極間部位

7, 107 : 反射器電極

8, 108 : I D T電極と反射器電極間部位

11, 111 : 入力信号端子

12, 112 : 接地端子

13, 113, 115 : 出力信号端子

21 : 接地端子または電気的浮き電極

22, 23 : 櫛歯状信号電極

51, 71 : 挿入損失の周波数特性

52, 72 : VSWRの周波数特性

61, 81 : 振幅の平衡度の周波数特性

62, 82 : 位相の平衡度の周波数特性

S2, S22, S23 : 平衡出入力部の信号線

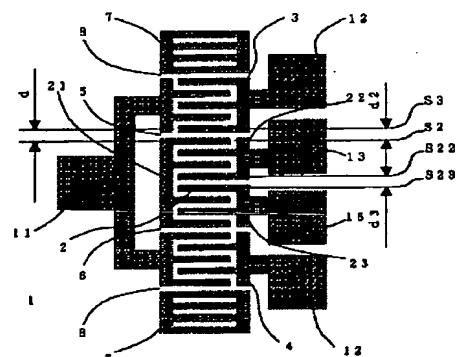
S3 : 不平衡出入力部の信号線

20 d : 電極指中心間の間隔

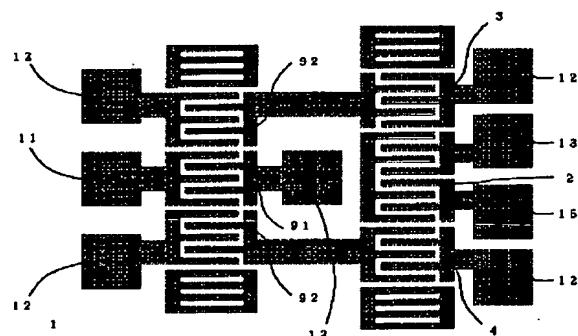
d2 : S2, S3の間隔

d3 : S22, S23の間隔

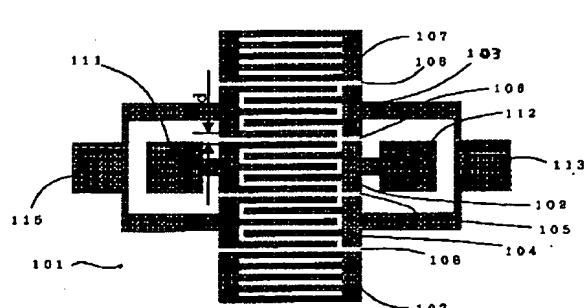
【図1】



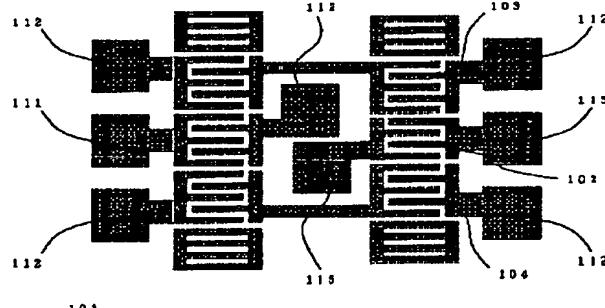
【図2】



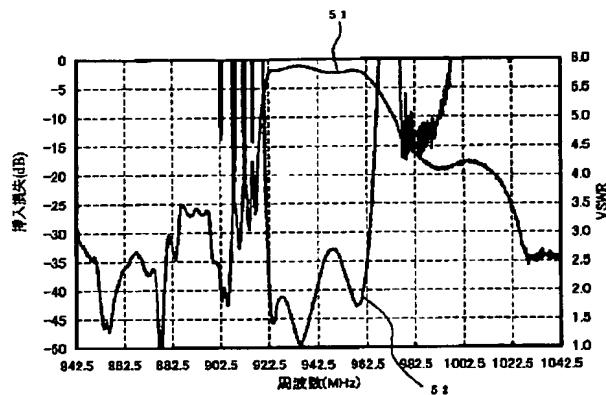
【図3】



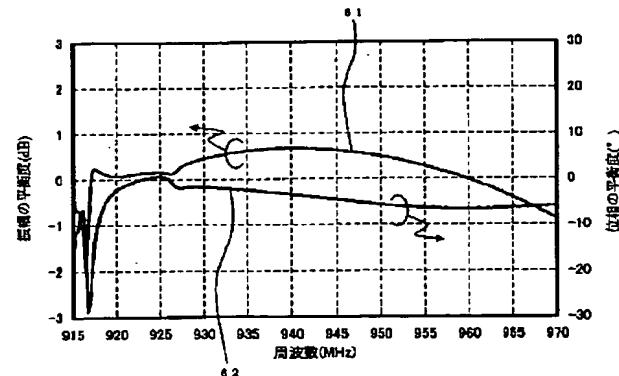
【図4】



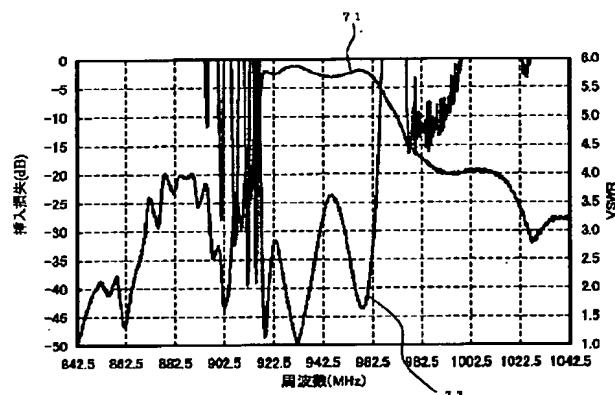
【図5】



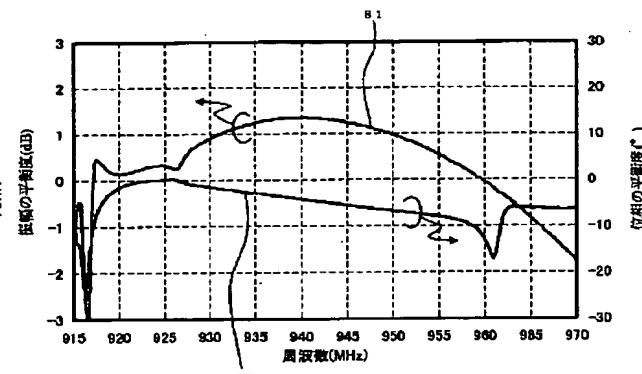
【図6】



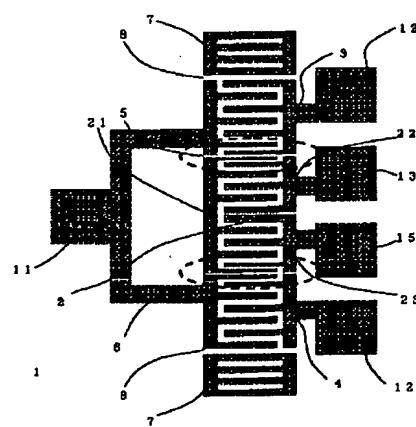
【図7】



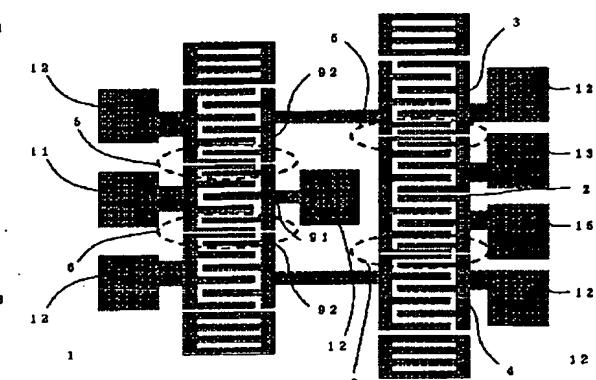
【図8】



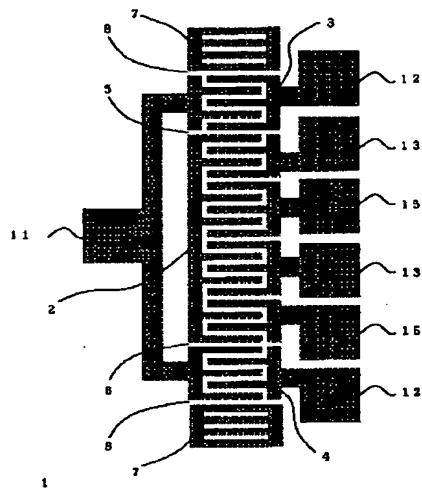
【図9】



【図10】



【図11】



PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-300004

(43)Date of publication of application : 11.10.2002

(51)Int.Cl. H03H 9/64

H03H 9/145

H03H 9/25

(21)Application number : 2001-096114 (71)Applicant : KYOCERA CORP

(22)Date of filing : 29.03.2001 (72)Inventor : ITO MIKI
OTSUKA KAZUHIRO

(54) SURFACE ACOUSTIC WAVE FILTER

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a surface acoustic wave filter that has an excellent insertion loss and has an excellent amplitude and phase balance characteristics.

SOLUTION: This invention provides the surface acoustic wave filter in which a balance signal electrode for balance input/output and an unbalance signal electrode for unbalance input/output is placed on a piezoelectric substrate 1, the balance signal electrode is formed by interdigitally opposing a plurality of interdigital signal electrodes among electrode fingers placed at both ends of one

interdigital floating electrode or interdigital ground electrode and the interdigital signal electrodes adjacent to each other are opposed to each other in phase.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] It is the surface acoustic wave filter of the resonator mold which arranges the balanced signal electrode which performs a balanced input or a balanced output, and the unbalance signal electrode which performs an unbalanced output or an unbalanced input, and changes on a piezo-electric substrate. While said balanced signal electrode makes it counter so that two or more ctenidium-like signal electrodes made to adjoin may be engaged and changes between the electrode fingers located in the ends of this electrode to one ctenidium-like float electrode or a ctenidium-like earth electrode The surface acoustic wave filter characterized by a ***** ctenidium-like signal electrode being an opposite phase mutually.

[Claim 2] The surface acoustic wave filter according to claim 1 characterized by the electrode fingers located in the edge of said ***** ctenidium-like signal electrode adjoining.

[Claim 3] The surface acoustic wave filter according to claim 1 characterized by making the average electrode digit from the center of said balanced signal electrode to the center of a ***** unbalance signal electrode smaller than the average electrode digit of the whole resonator.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the surface acoustic wave filter of the resonator mold which is equipped with the balanced signal electrode which performs a balanced input or a balanced output, and the unbalance signal electrode which performs an unbalanced output or an unbalanced input, and changes on a piezo-electric substrate.

[0002]

[Description of the Prior Art] In recent years, for small and lightweight-izing of mobile communication equipment etc., and low-cost-izing, the cutback of activity components is advanced and addition of a new function has been required of a surface acoustic wave filter. One of them has a demand of enabling it to constitute in an unbalanced input-balanced output mold or a balanced input-unbalanced output mold. A balanced input or a balanced output means what a signal inputs or outputs as the potential difference between two signal-line ways here, the signal of each signal-line way has the equal amplitude, and the phase is an opposite phase. On the other hand, an unbalanced input or an unbalanced output means what a signal inputs or outputs as potential of one line over ground potential.

[0003] The conventional surface acoustic wave filter had taken the circuitry which inserted the unbalance-balanced converter (henceforth a balun) between a surface acoustic wave filter and the latter part, when the circuit and electronic parts which are connected to the latter part of a surface acoustic wave filter had become a balanced input mold, since it was generally an unbalanced input-unbalanced output mold surface acoustic wave filter (henceforth an unbalance

mold surface acoustic wave filter). When the circuit and electronic parts of the surface acoustic wave filter preceding paragraph had become a balanced output mold similarly, it had become circuitry which inserted the balun between the preceding paragraph and a surface acoustic wave filter.

[0004] In order to delete current and a balun, utilization of the unbalanced input-balanced output mold surface acoustic wave filter which gave the unbalance-balance conversion function or balanced - unbalance conversion function to the surface acoustic wave filter, or a balanced input-unbalanced output mold surface acoustic wave filter (henceforth a balanced type surface acoustic wave filter) is advanced.

[0005] For example, in the resonator mold electrode pattern with which the reflector electrode for resonating a surface acoustic wave efficiently was prepared in the ends of the surface acoustic wave propagation path of the installed IDT (Inter Digital Transducer) electrode, improvement in the amplitude in a passband and the unbalance of a phase is called for. Here, a signal inputs or outputs the amplitude and the unbalance of a phase as the potential difference between two signal-line ways, the unbalance of the amplitude is excellent, so that its magnitude of the amplitude of the signal of each signal-line way is equal, and it can be said that the unbalance of a phase is excellent, so that the difference of the phase of each signal is equal to 180 degrees.

[0006] The resonator mold surface acoustic wave filter corresponding to the balanced I/O to the former is shown in drawing 3 and 4. The IDT electrode 102 arranged on the piezo-electric substrate 101 adds electric field to the ctenidium-like electrode made to counter mutually [a couple], and excites a surface acoustic wave. By the principle, the excited surface acoustic wave spreads by applying an input signal to the IDT electrode 102 to the IDT electrode 103,104 for output signals located in the both sides of the IDT electrode 102. The propagation balanced output of the signal is carried out from the output signal terminal 113 and another side from one pectinate form electrode of the IDT electrodes 103 and 104 to the output signal terminal 115. Moreover, drawing 4

has composition which can perform improvement in the magnitude of attenuation of a filter shape out of band, when two steps connect.

[0007] Since structures, such as an electrode pattern of the circumference used as the electrode number of the pectinate form electrode with which the IDT electrodes 103 and 104 counter, the arranged location, or the factor which generates parasitic capacitance, differed, with the above resonator mold surface acoustic wave filters, only the resonator mold surface acoustic wave filter with which amplitude differed [the signal which gets across to the output signal terminals 113 and 115] mutually, the phase shifted from the opposite phase, consequently unbalance deteriorated was obtained.

[0008] In recent years, the surface acoustic wave filter is bearing a part to the miniaturization of various communication equipment, and no adjusting-ization. And the demand of broadband-izing of a surface acoustic wave filter has been growing increasingly with progress of high-frequency-izing of communication equipment, and advanced features. For example, as a filter for 900MHz band cellular phones, the highly efficient broad band filter with an effective pass band width of 35MHz or more (about 3.7% or more of fractional band width) is demanded. In addition, fractional band width BR can be expressed with $BR = BW/fc$ (pass band width [in / BW / in band interpolation close loss / 3dB], center frequency of a passband [in / fc / in band interpolation close loss / 3dB]).

[0009] In order to realize such broadband-ization, various approaches are proposed conventionally. For example, three IDT (Inter Digital Transducer) electrodes (electrode which one pair of ctenidium-like electrodes were made to counter mutually) are prepared, and the so-called double mode surface acoustic wave resonator filter using primary length mode and 3rd length mode is known.

[0010] As shown in drawing 3 , a surface acoustic wave is reflected by the reflector electrode 107 located in ends, and it becomes a standing wave between the reflector electrodes 107,107. The primary mode and its high order (3rd order) mode are contained in the mode of this standing wave with three IDT electrodes. Since a passage property is acquired with the resonance frequency generated in

these modes, a passband can be made large by controlling spacing of resonance frequency. In addition, for an IDT inter-electrode part and 108, as for an input signal terminal and 112, an IDT electrode, a reflector inter-electrode part, and 111 are [105,106 / an earth terminal and 113,115] output signal terminals among drawing.

[0011] Conventionally, the approach of controlling the frequency between the aforementioned modes by control of the spacing d of the electrode finger center to center in the edge (IDT inter-electrode part) 105,106 of the IDT electrode which makes all IDT electrodes the same pitch L , and is located in the frequency control between this mode at a center and its both sides was taken. Moreover, capacity was added to the IDT electrode for output signals, and the frequency was controlled.

[0012] For this reason, with the conventional double mode surface acoustic wave resonator filter, when the substrate of LiTaO₃ single crystal was used, for example as a piezo-electric substrate, fractional band width (value of the pass band width to center frequency) was obtained only about 0.40% (see JP,1-231417,A) or at most about 2% (see JP,4-40705,A). Moreover, although 3.7% was realized with the greatest bandwidth (see JP,7-58581,A), since the ratio of the occupancy bandwidth of a system was 3.7% as described above, there was a problem in application to communication equipment, such as a cellular phone with which large pass band width is demanded from the amount of [of temperature fluctuation and the dispersion fluctuation at the time of production] frequency being required as a filter.

[0013] Then, this invention can operate as a balanced type and aims at offering a surface acoustic wave filter with the good and quality unbalance of the amplitude and a phase, and the outstanding surface acoustic wave filter which an insertion loss is still better and can function as surface acoustic wave filters with wide pass band width.

[0014]

[Means for Solving the Problem] In order to attain said object, the surface

acoustic wave filter of the resonator mold of this invention On a piezo-electric substrate, the balanced signal electrode which performs a balanced input or a balanced output, and the unbalance signal electrode which performs an unbalanced output or an unbalanced input are arranged, and it changes. Said balanced signal electrode While making it counter so that two or more ctenidium-like signal electrodes made to adjoin may be engaged and changing between the electrode fingers located in the ends of this electrode to one ctenidium-like float electrode or a ctenidium-like earth electrode, it is characterized by a ***** ctenidium-like signal electrode being an opposite phase mutually. Moreover, it is characterized by the electrode fingers located in the edge of a ***** ctenidium-like signal electrode adjoining. Moreover, it is characterized by making the average electrode digit from the center of a balanced signal electrode to the center of a ***** unbalance signal electrode smaller than the average electrode digit of the whole resonator.

[0015]

[Embodiment of the Invention] Hereafter, it explains to a detail based on the drawing which illustrated the operation gestalt of this invention typically.

[0016] The top view of the surface acoustic wave filter applied to this invention at drawing 1 is shown. Although it is the same as that of structure conventionally to carry out two or more arrangement of the IDT electrode 2 which is the IDT electrodes 3 and 4 and the balanced signal electrode which are an unbalance signal electrode, and to make the reflector electrode 7 lay in the ends With the structure of this invention, the IDT electrode 2 between the electrode fingers located in the ends of the electrode to one ctenidium-like float electrode or the ctenidium-like earth electrode 21 While making it counter so that two or more ctenidium-like signal electrodes 22 and 23 made to adjoin may be engaged and changing, it is constituted so that the ***** ctenidium-like signal electrodes 22 and 23 may grow into an opposite phase mutually, and each polar zone is formed as a balanced signal electrode. It is characterized by controlling the amplitude and phase balance by the above-mentioned structure. In addition, the

number of the electrode finger of the IDT electrodes 2, 3, and 4 and the reflector electrode 7 is simplifying and illustrating the configuration in order to attain to several - no less than 100 numbers. Hereafter, in the drawing in which a surface acoustic wave filter is shown, it shall simplify similarly and all shall be illustrated.

[0017] Here, the IDT electrode 2 arranged in the center among three IDT electrodes 2-4 is an object for unbalanced inputs, or an IDT electrode for unbalanced outputs, and the IDT electrodes 3 and 4 arranged to the ends are an object for balanced inputs, or an IDT electrode for balanced outputs, respectively. If one side is an output 1 among one pair of electrodes which form the IDT electrode for an output, another side will serve as the output 2 from which the phase is an opposite phase in the magnitude with the same amplitude to an output 1, and will operate a balanced type.

[0018] The place which investigated the spacing d2 of the signal line S3 of the unbalance I/O section, and the signal line S2 of the balanced appearance input section, and correlation of a filter shape, Interference of such mutual electromagnetic field that d2 becomes large becomes small, and, as a result, the amplitude of the balanced appearance input section and the unbalance of a phase are improved. Conversely, the propagation loss of a surface acoustic wave becomes small, so that d2 becomes small, and as a result, the insertion loss of a filter shape becomes small. The optimal structure had the smallest insertion loss in the place which becomes equal to $\lambda+d$, when d2 set wavelength of a surface acoustic wave to λ , and it became clear that the unbalance of the amplitude and a phase also became good.

[0019] Moreover, when investigated also about the spacing d3 of the signal lines S22 and S23 of the two balanced appearance input sections, it became clear that the insertion loss of a filter shape became small, so that the electrode fingers located in the edge of a ***** ctenidium-like signal electrode adjoined and d3 approached $\lambda/2$. That is, it became clear by making it the structure of this invention that the surface acoustic wave filter excellent in the insertion loss of a filter shape and the unbalance of the amplitude and a phase could be offered.

[0020] Next, the modification of the electrode configuration of this invention is shown in drawing 2 , and 9, 10 and 11.

[0021] Drawing 2 is the surface acoustic wave filter which connected two steps of resonator mold filters. An unbalance signal is inputted into the IDT electrode 91 which is an unbalance signal electrode, and an unbalance signal is outputted from the IDT electrode 92. And the IDT electrode 92 and the unbalance signal electrodes 3 and 4 of the next resonator mold filter are connected. The magnitude of attenuation of a filter shape out of band can be greatly raised according to the above-mentioned structure.

[0022] Drawing 9 is characterized by making the average electrode digit of the IDT inter-electrode parts 5 and 6 from the center of the balanced signal electrode 2 to the center of the ***** unbalance signal electrodes 3 and 4 smaller than the average electrode digit,of the whole resonator. The pass band width of a filter shape is controllable by the above-mentioned structure.

[0023] It is characterized by for drawing 10 having connected two steps of resonator mold filters, and making smaller than the average electrode digit of the whole resonator the average electrode digit of the IDT inter-electrode parts 5 and 6 from the center of the IDT electrode 2 which is a balanced signal electrode to the center of the IDT electrodes 3 and 4 which are ***** unbalance signal electrodes. The magnitude of attenuation of a filter shape out of band can be greatly raised according to the above-mentioned structure, and the pass band width of a filter shape can be controlled further.

[0024] according to the surface acoustic wave filter of the IDT electrode structure of satisfying the above conditions in this way -- an IDT electrode -- the filter became the combination by which the logarithm was optimized, consequently the property of the unbalance of fractional band width, the amplitude, and a phase excelled [filter] in the good quality target is producible.

[0025] Drawing 11 is characterized by engaging four ctenidium-like electrodes of a balanced signal electrode. Thereby, by using four electrodes, a design parameter can be increased and the design which was more suitable for

requirement specification can be performed.

[0026] In addition, although the surface acoustic wave filter was constituted from a resonator of one section in drawing 1, it is not limited to this and this invention can be applied also in the surface acoustic wave filter which put in order the surface acoustic wave filter which carried out two or more piece cascade connection of the resonator, and five or more IDT electrodes.

[0027] Moreover, it is not what is limited also to setting in the electrode structure of drawing 2 and the surface acoustic wave filter of 9, 10, and 11. While arranging at least three IDT electrodes between two reflector electrodes If the IDT electrode which makes the IDT electrode located in the center among these three IDT electrodes the unbalanced input section or the unbalanced output section, and is located in ends is made into the balanced output section or the balanced input section, it can also constitute in an a large number stage.

[0028] Moreover, as a piezo-electric substrate 1 for surface acoustic wave filters, since [that its electromechanical coupling coefficient is large and] a 36 degrees **3 degreeY cut X propagation lithium tantalate single crystal, a 42 degrees **3 degreeY cut X propagation lithium tantalate single crystal, a 64 degrees **3 degreeY cut X propagation lithium niobate single crystal, a 41 degrees **3 degreeY cut X propagation lithium single crystal, and a 45-degreeX [**3 degree] cut Z propagation tetraboric-acid lithium single crystal have the small frequency temperature coefficient, they are desirable as a piezo-electric substrate. The thickness of a piezo-electric substrate has 0.1mm - about 0.5 goodmm, and by less than 0.1mm, a piezo-electric substrate cannot become weak, by 0.5mm **, ingredient cost and a components dimension become large and it cannot be used.

[0029] Moreover, the IDT electrodes 2, 3, and 4 consist of aluminum or an aluminum alloy (an aluminum-Cu system, aluminum-Ti system), and are formed by the thin film forming methods, such as vacuum deposition, a spatter, or a CVD method. Electrode thickness is suitable when being referred to as 0.1 micrometers - about 0.5 micrometers acquires the property as a surface acoustic

wave filter.

[0030] Furthermore, Si, SiO₂, SiNx, and aluminum 2O₃ may be formed in the surface acoustic wave propagation section on the electrode of the surface acoustic wave filter concerning this invention, and a piezo-electric substrate as a protective coat, and the energization prevention and the improvement in power-proof by the conductive foreign matter may be performed.

[0031]

[Example] The example which made concretely the surface acoustic wave filter concerning this invention as an experiment is explained.

[0032] On the piezo-electric substrate of LiTaO₃ single crystal of 38.7 degreeY cut, the detailed electrode pattern by aluminum(99wt%)-Cu (1wt%) as shown in drawing 1 was formed. As for the logarithm of the IDT electrode 2, the spacing d of the electrode finger center to center in the edge of the IDT electrode between 2.1 micrometers and the IDT electrode 2-3 or between 2-4 set the period of 11 pairs and an electrode to 3.3 micrometers for the IDT electrodes 2, 3, and 4, as for the logarithm of 16 pairs and the IDT electrodes 3 and 4. A sputtering system, a reduced-projection-exposure machine (stepper), and RIE (Reactive Ion Etching) equipment performed the photolithography in pattern production.

[0033] First, the substrate ingredient was cleaned ultrasonically by the acetone, IPA, etc., and the organic component was dropped. Next, after clean oven fully performed substrate desiccation, membrane formation of an electrode was performed. The sputtering system was used for membrane formation of an electrode, and the ingredient which consists of an aluminum-Cu1wt% alloy was used. The electrode layer thickness at this time could be about 0.2 micrometers.

[0034] Next, the spin coat of the photoresist was carried out to the thickness of about 0.5 micrometers, after having carried out patterning to the request configuration, dissolving the photoresist of a garbage with the alkali developer with the developer and expressing a request pattern with a cutback projection aligner (stepper), the electrode layer was etched with RIE (Reactive Ion Etching) equipment, pattern NINGU was ended, and the electrode pattern of the surface

acoustic wave resonator which constitutes a ladder mold surface acoustic wave filter was obtained.

[0035] Then, the protective coat was produced on the predetermined field of said electrode. That is, SiO₂ was formed on the electrode pattern and the piezo-electric substrate with CVD (Chemical Vapor Deposition) equipment at the thickness of about 0.02 micrometers. Then, by the photolithography, patterning of a photoresist was performed, ***** for wirebonding was etched with the RIE system etc., and the protective coat pattern was completed.

[0036] Next, dicing processing was performed along with the dicing line, and the substrate was divided for every chip. And each chip was taken up with die bond equipment, and it pasted up in the package using the resin which uses silicone as a principal component. Then, desiccation and hardening of were done in the temperature of about 160 degrees C. The package used the thing of the laminated structure of 3mm angle.

[0037] Next, after carrying out ball bonding of the 30micrometerphiAu wire on aluminum electrode pad on the polar zone of a package, and a chip, the lid was put on the package, welding closure was carried out with the closure machine, and the surface acoustic wave filter was completed. In addition, it dissociated respectively, and the grand electrode on a chip wired, and performed bonding to the grand electrode on a package in Au ball bonding.

[0038] The detailed electrode pattern as shown in drawing 3 as a sample for a comparison also produced at the same process as the above. As for the logarithm of the IDT electrode 102, the spacing d of the electrode finger center to center in the edge of the IDT electrode between 2.1 micrometers and the IDT electrode 102-103 or between 102 -104 set the period of 11 pairs and an electrode to 3.3 micrometers for the IDT electrode 102,103,104, as for the logarithm of 16 pairs and the IDT electrode 103,104.

[0039] Next, property measurement of the surface acoustic wave filter in this example was performed. The 0dBm signal was inputted and it measured on the conditions of a 842.5MHz - 1042.5 MHz frequency and 801 points of measure

point numbers and the frequency of 10MHz - 6GHz, and the conditions of 401 points of measure points. A measurement size is 30 pieces and measuring equipment is network analyzer by horse mackerel RENTO technology company 8753D.

[0040] The frequency-characteristics graph near the passband is shown in drawing 5 and 6. Here, drawing 5 is a graph which shows frequency dependent [of the ratio VSWR (Voltage Standing Wave Ratio) which evaluates frequency dependent / of the insertion loss showing the transmission characteristic of a filter / (51 in drawing), and the magnitude of a reflective signal] (52 in drawing). Moreover, drawing 6 is a graph which shows the unbalance of a filter shape, and makes the unbalance of the amplitude the difference of the frequency characteristics of the insertion loss outputted from the output signal terminal 13, and the frequency characteristics of the insertion loss outputted from the output signal terminal 15. Moreover, let the value which deducted 180 degrees from the difference of the frequency characteristics of the phase outputted from the output signal terminal 13, and the frequency characteristics of the phase outputted from the output signal terminal 15 be the unbalance of a phase. It can be estimated that the unbalance of a surface acoustic wave filter is excellent, so that the unbalance of the amplitude is 0dB and the unbalance of a phase is 0 degree.

[0041] The filter shape of this invention article was dramatically good. As shown in drawing 6 , in the passband, the unbalance 61 with an amplitude of 925MHz - 960MHz was about **0.7dB or less, and the unbalance 62 of a phase was about **7 degrees or less. On the other hand, conventionally which was produced as a comparison sample, in the passband, the unbalance 81 with an amplitude of 925MHz - 960MHz was about **1.4dB or less, and the unbalance 82 of a phase was about **15 degrees or less as the surface acoustic wave filter of structure was shown in drawing 7 and 8. The improvement (about 0.7dB and about 8 degrees) was found, respectively. Moreover, to the passband insertion loss 51 of this invention article being about 2.4dB or less, and VSWR52 being 2.7 or less, conventionally, the insertion loss 71 of about 3.1dB or less and VSWR72 is 3.6 or

less, and, as for elegance, the improvement of about 0.7dB and 0.9 was found, respectively.

[0042] Moreover, since the miniaturization of a surface acoustic wave filter was demanded, the surface acoustic wave filter of the above-mentioned example was produced by flip chip mounting, and it evaluated. That is, after forming a protective coat pattern, the bump of Au was formed in the electrode pattern for bump formation with bump formation equipment. Next, the surface acoustic element was separately started by dicing. Next, with flip-chip-bonding equipment, the surface acoustic element started separately was pasted up in one and a ceramic package, and BEKU was performed to the ceramic package of 2.5x2.0mm angle in N2 ambient atmosphere. Next, the metal cap was put on the package with the sealing arrangement, the inside of a package was sealed, and the surface acoustic wave filter was produced. As a result of measuring the property of the filter of the above-mentioned structure, it has checked that the same result as the above was obtained.

[0043]

[Effect of the Invention] As explained above, the surface acoustic wave filter of this invention is a surface acoustic wave filter of a resonator mold, and a balanced signal electrode is characterized by a ***** ctenidium-like signal electrode being an opposite phase mutually while it is made to counter so that two or more ctenidium-like signal electrodes made to adjoin may be engaged and changes between the electrode fingers located in the ends of this electrode to one ctenidium-like float electrode or a ctenidium-like earth electrode. Interference of the electromagnetic field of an unbalance electrode and a balanced electrode can be made small, consequently a balanced signal can be controlled by configuration of the above-mentioned structure in which a ctenidium-like float electrode or a ctenidium-like earth electrode is especially located in the ends of a balanced signal electrode, and the surface acoustic wave filter the unbalance of the amplitude and a phase excelled [filter] in the good quality target can be realized.

[0044] Moreover, the surface acoustic wave filter of this invention is characterized by the electrode fingers located in the edge of a ***** ctenidium-like signal electrode adjoining. The surface acoustic wave filter of this invention is characterized by the thing which can realize the surface acoustic wave filter could bring the difference of the phase of the balanced signal electrodes 22 and 23 close to 180 degrees, consequently the unbalance of a phase excelled [filter] in the good quality target and for which the average electrode digit from the center of a balanced signal electrode to the center of a ***** unbalance signal electrode was made smaller than the average electrode digit of the whole resonator by controlling spacing of the electrode finger of the above-mentioned structure again. The primary length mode of a surface acoustic wave and 3rd length mode are controllable by changing the average electrode digit of the above-mentioned structure, respectively.

[0045] The surface acoustic wave filter which broadband-ized pass band width of a filter shape and which was excellent in quality is realizable with the above.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing typically the example of a configuration of the surface acoustic wave filter of this invention.

[Drawing 2] It is the top view showing typically the example of a configuration of two-step connection of the surface acoustic wave filter of this invention.

[Drawing 3] It is the top view showing the example of a configuration of the conventional surface acoustic wave filter.

[Drawing 4] It is the top view showing the example of a configuration of two-step connection of the conventional surface acoustic wave filter.

[Drawing 5] It is the graph which shows the frequency characteristics near [in the surface acoustic wave filter of this invention] the passband.

[Drawing 6] It is the graph which shows the amplitude near [in the surface acoustic wave filter of this invention] the passband, and the unbalance of a phase.

[Drawing 7] It is the graph which shows the frequency characteristics near [in the conventional surface acoustic wave filter] the passband.

[Drawing 8] It is the graph which shows the amplitude near [in the conventional surface acoustic wave filter] the passband, and the unbalance of a phase.

[Drawing 9] It is the electrode block diagram showing typically the surface acoustic wave filter of the one-step configuration concerning this invention.

[Drawing 10] It is the electrode block diagram showing typically the surface acoustic wave filter of the two-step connection concerning this invention.

[Drawing 11] It is the electrode block diagram showing typically the modification of the surface acoustic wave filter concerning this invention.

[Description of Notations]

1,101 : piezo-electric substrate

2, 3, 4, 91, 92, 102, 103, 104 : IDT electrode

5, 6, 105, 106 : IDT inter-electrode part

7, 107 : reflector electrode

8, 108 : an IDT electrode and reflector inter-electrode part

11,111 : input signal terminal
12,112 : earth terminal
13 15,113,115 : Output signal terminal
21 : Earth Terminal or Electric Float Electrode
22 23 : Ctenidium-like signal electrode
51 71 : Frequency characteristics of an insertion loss
52 72 : Frequency characteristics of VSWR
61 81 : Frequency characteristics of the unbalance of the amplitude
62 82 : Frequency characteristics of the unbalance of a phase
S2, S22, S23 : Signal line of the balanced appearance input section
S3 : Signal line of the unbalance I/O section
d : spacing of an electrode finger center to center
d2 : Spacing of S2 and S3
d3 : Spacing of S22 and S33

[Translation done.]

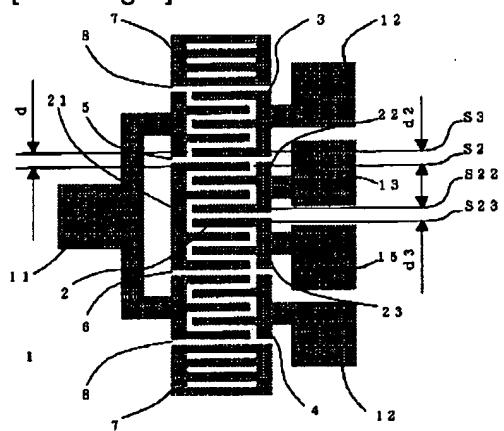
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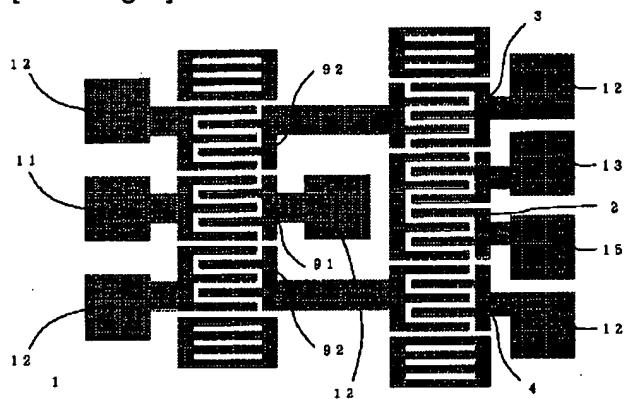
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DRAWINGS

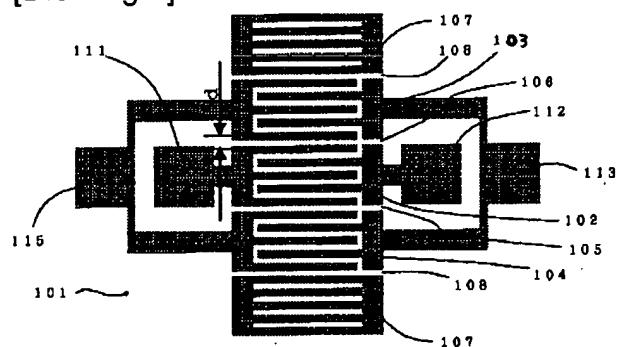
[Drawing 1]



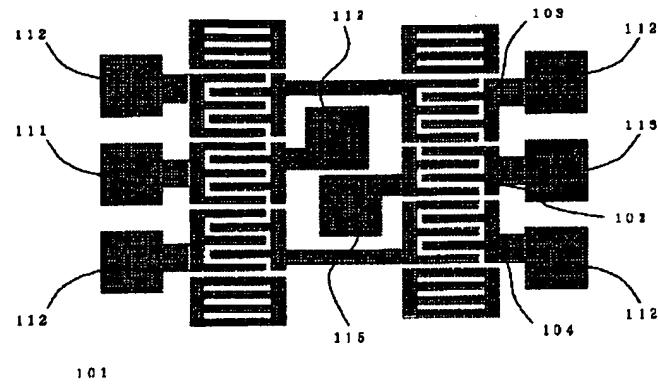
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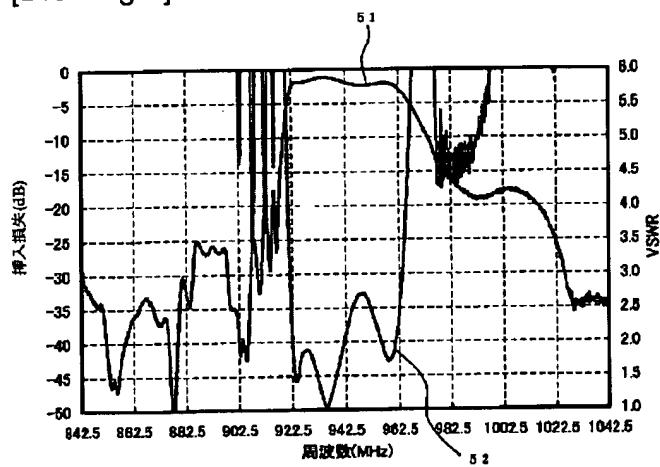
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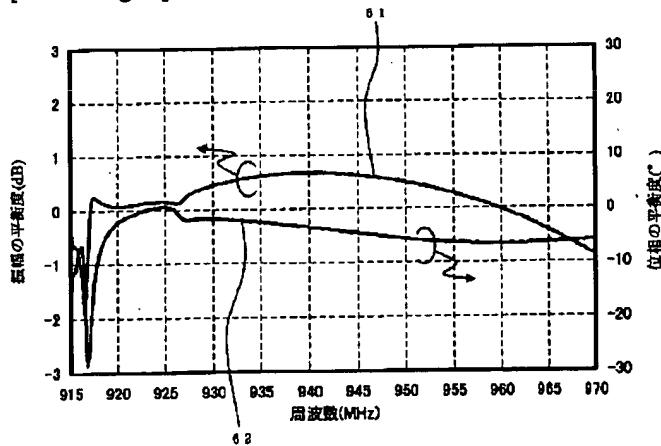
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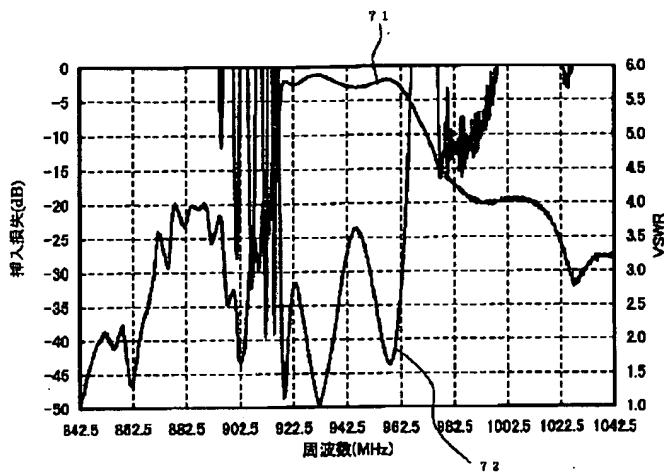
[Drawing 5]



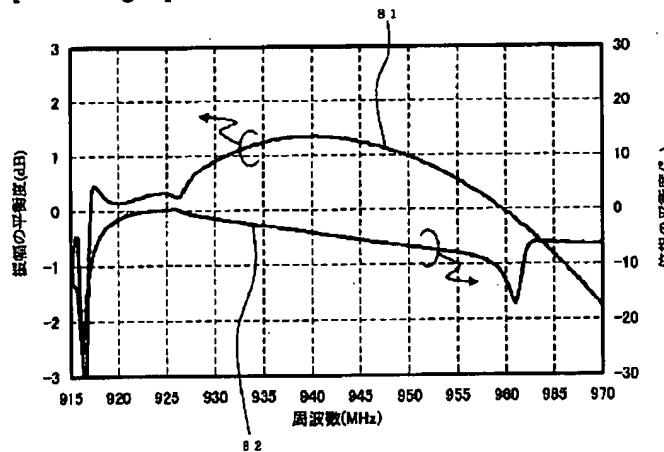
[Drawing 6]



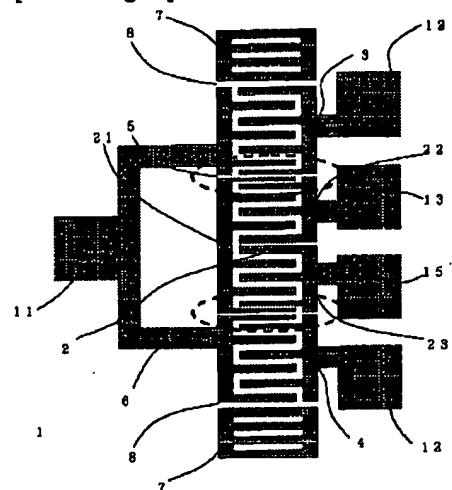
[Drawing 7]



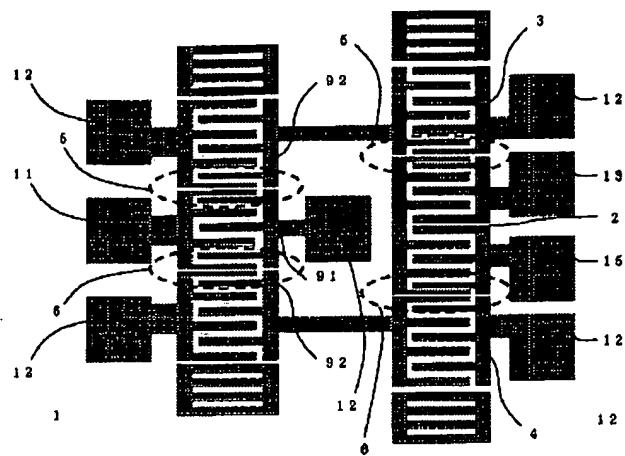
[Drawing 8]



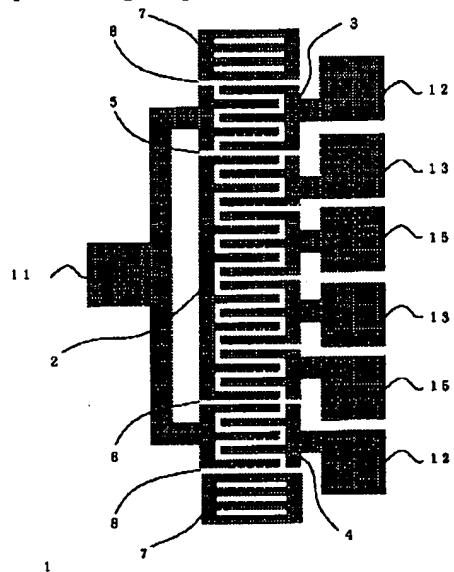
[Drawing 9]



[Drawing 10]



[Drawing 11]



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